VOLUME VI: CHAPTER 1

INTRODUCTION: THE VALUE OF QA/QC

Final Report

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DISCLAIMER

This document was furnished to the Emissions Inventory Improvement Program (EIIP) and U.S. Environmental Protection Agency by Eastern Research Group, Morrisville, North Carolina. This report is intended to be a final document and has been reviewed and approved for publication. The opinions, findings, and conclusions expressed represent a consensus of the members of the Emissions Inventory Improvement Program. Mention of company or product names is not to be considered as an endorsement by the U.S. Environmental Protection Agency.

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BACKGROUND

The Clean Air Act (CAA) requires state and local air quality agencies to develop complete and accurate inventories as an integral part of their air quality management responsibilities. These air emission inventories are used to evaluate air quality, track emission reduction levels, and set policy on a national and regional scale; however, they are often developed and compiled on a local level by multiple agencies and individuals. Experience with the 1990 State Implementation Plan (SIP) base year inventories brought to light deficiencies and inconsistencies in the inventory development processes now being used. In addition, the current leeway in selecting these processes has resulted in data sets of unknown quality and varying degrees of completeness. More uniform and systematic approaches to collecting and reporting data are needed as well as, standardized procedures and guidance to eliminate variations in interpretation.

To address the problems of the current inventory processes and comply with the CAA, the U.S. Environmental Protection Agency (EPA), in conjunction with State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officers (STAPPA/ALAPCO), has established the Emission Inventory Improvement Program (EIIP). The EIIP comprises several committees with representatives from state and local agencies, EPA, and industry. Its main goal is to improve the quality of the emissions data collected as well as the manner in which data and information are transferred and shared.

The EIIP Quality Assurance Committee was formed to develop (1) a plan for the EIIP's quality assurance (QA) program, (2) a comprehensive QA source document of methodologies and tools for use in developing emission inventories, and (3) an emission inventory quality rating system. This volume is the EIIP QA source document; it incorporates all products prepared by the EIIP QA Committee including a model QA plan and a quality rating system.

It is important to recognize that good quality assurance/quality control (QA/QC) procedures will only produce results that are as good as the estimation methodology allows. Some emissions estimates are inherently more accurate than others because they are based on well-defined and well-understood processes and/or source-specific data. For example, annual emissions estimates for a boiler with a continuous emissions monitor (CEM) should be of higher quality than estimates based on fuel use and an emission factor. QA/QC procedures are required to ensure confidence in the estimates from both types of methods. However, the QA/QC procedures required for the CEM data are more detailed and time-consuming than those required for the emission factor approach, just as more effort is expended in acquiring the CEM data.

Because of the different emissions estimating methods that can be used, the EIIP recognized that an inventory quality program had to address both emissions estimation uncertainty and data quality. Uncertainty is largely a function of the estimation methodology. The quality of an estimate is determined partly by the inherent uncertainty of the method as well as by the procedures used to ensure that errors are minimized. Therefore, the EIIP QA Committee worked with the Point, Area, and Mobile Sources Committees to ensure that inherent uncertainties in the emission estimation methods are discussed as fully as possible in each chapter of the appropriate emissions estimation volumes (Volumes II, III, and IV).

In addition, a data attribute rating system (DARS), originally developed by the EPA's Air Pollution Prevention and Control Division (APPCD) as a research tool, was adapted and used to rank the EIIP point and area source methods. The DARS scores provide a means of assessing the relative merits of alternative approaches. The general issues associated with uncertainty were also addressed by the EIIP's QA program. The uses of uncertainty analysis and of rating systems such as DARS are encouraged by the EIIP QA program. These methods can serve as indicators of data quality, be used to identify appropriate estimation methods, and help determine which sources are in need of improvement. Also, Chapter 4 of this volume focuses on the determination and evaluation of uncertainty in emission estimates and the methodology available to do this.

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THE QA PROGRAM AND ITS IMPORTANCE

QA activities are essential to the development of comprehensive, high-quality emission inventories for any purpose. Furthermore, a well-developed and well-implemented QA program fosters confidence in the inventory and any resulting regulatory and/or control program.

An overall QA program comprises two distinct components. The first component is that of quality control (QC), which is a system of routine technical activities implemented by inventory development personnel to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

Provide routine and consistent checks and documentation points in the inventory development process to verify data integrity, correctness, and completeness;

Identify and reduce errors and omissions;

Maximize consistency within the inventory preparation and documentation process; and

Facilitate internal and external inventory review processes.

QC activities include technical reviews, accuracy checks, and the use of approved standardized procedures for emission calculations. These activities should be included in inventory development planning, data collection and analysis, emission calculations, and reporting.

The second component of a QA program consists of external QA activities, which include a planned system of review and audit procedures conducted by personnel not actively involved in the inventory development process. The key concept of this component is independent, objective review by a third party to assess the effectiveness of the internal QC program and the quality of the inventory, and to reduce or eliminate any inherent bias in the inventory processes. In addition to promoting the objectives of the QC system, a comprehensive QA review program provides the best available indication of the inventory's overall quality completeness, accuracy, precision, representativeness, and comparability of data gathered.

A common failure of many inventory development programs is that inadequate resources are devoted to QA/QC activities. A rule of thumb used by many QA professionals is that 10 percent of the in-kind resources of any project should be allocated to QA activities. This does not include the costs of QC, which are assumed to be built into the process.

The actual amount of effort spent in QA/QC of an inventory will vary depending on the desired quality and the complexity of the inventory. However, QA/QC efforts will generally be proportional to the effort expended on emission calculation. For example, estimating an area source's volatile organic compound emissions using simple activity data (such as population) and an emission factor requires relatively little effort for both the calculation and the QA/QC checks. If a survey of local sources is used, resource expenditures for the calculation are increased. Given that more resources are invested in emissions calculations, it is logical to also invest more heavily in ensuring the quality of the data.

It is essential to have a written plan for both the inventory preparation and the QA/QC procedures. Planning includes an assessment of resources and available information. The purpose and end-use of an inventory will dictate the data quality objectives (DQOs). (See Chapter 4 of this volume for more information about DQOs.) The DQOs and available information and resources will determine QA/QC procedures and the scope of the effort.

Simple QA procedures, such as checking calculations and data input, can and should be implemented early and often in the process. More comprehensive (but also more expensive) procedures should target:

Critical points in the process;

Critical components of the inventory (e.g., larger or more important sources); and

Areas or activities where problems are anticipated (e.g., if a complex model is being used for the first time).

Too often, QA activities are concentrated at the end of the inventory process. An effective QA program will include planning, numerous QC checks during inventory development, and QA audits at strategic points in the process. These strategic points need to be identified in the planning stage and will vary somewhat between agencies and inventories. However, the ideal QA program would include at least one audit conducted after the planning is completed and before the emissions calculations are more than 25 percent completed; another should occur near the end of the process to assure that the final products meet the DQOs. Other audits between these two points are desirable, but the exact scope, timing, and number of audits will depend on the DQOs and resources available as well as the procedures and methods being used to estimate emissions.

Failure to implement and adhere to a QA program will almost certainly lead to undesirable consequences, such as:

> Contamination of subsequent calculations and decisions because of mistakes missed early in the process;
>
> Increased cost because work has to be redone;
>
> An incomplete and/or inaccurate inventory even if work is redone;
>
> Obstruction of the rule-making and enforcement processes;
>
> Establishment of regulations that are not realistic (emission estimates are based on incorrect emission factors, emissions overestimated or allocated to wrong processes); and
>
> Embarrassment to all concerned.

Therefore, the EIIP QA program strongly recommends that inventory personnel obtain the commitment of their management to the quality program. This will require the commitment of resources to provide training and proper equipment (e.g., computers) as well as providing sufficient time for the inventory staff to get the work done. This commitment of time and resources will ultimately pay off. In a presentation at a 1994 Air and Waste Management Association conference, Boothe and Chandler (1994), described the careful steps used by the North Carolina Division of Environmental Management (NCDEM) to quality assure emissions data for use in urban airshed modeling. The authors conclude:

> Although the QA process can take significant time and effort . . . [it] will save time ultimately by reducing the processing of invalid emission files. In addition, a thorough QA system ensures confidence in the modeling results . . . [which] provides more confidence in the resulting regulatory decisions.

The critical role played by management in supporting and maintaining quality systems is the core of the emerging environmental management standards under development by the International Standards Organization (ISO). ISO 14000 standards can be categorized into five groups: environmental management systems, environmental audits, environmental performance evaluation, environmental labeling, and life cycle assessment. Because these standards are voluntary, they are not prescriptive. Environmental Management Systems, the first standard (ISO 14001), requires conformance to the elements shown in Figure 1.2-1. The standard states that "top management" must define the organization's environmental policy. Among other things, the policy must ensure continual improvement, must provide a framework for setting and reviewing objectives, and must be documented.

Environmental Management System Requirements

I. Environmental Policy

II. Planning
- A. Environmental aspects
- B. Legal and other requirements
- C. Objectives and targets
- D. Environmental management programs

III. Implementation and Operation
- A. Structure and responsibility
- B. Training, awareness, and competence
- C. Communication
- D. Environmental management system documentation
- E. Document control
- F. Operational control
- G. Emergency preparedness and response

IV. Checking and Corrective Action
- A. Monitoring and measurement
- B. Nonconformance and corrective and preventative action
- C. Records
- D. Environmental management system audit

V. Management Review

FIGURE 1.2-1. ELEMENTS OF ISO 14001

ISO 14000 does not set environmental standards or criteria; rather, it specifies a system for managing environmental quality. As ISO 14000 standards are developed in the future, the EIIP QA guidance should be compatible with the standard. In particular, the EIIP has looked for ways to address the concept of continual improvement in emission inventory quality and to introduce quantitative measures of the quality of emissions estimates so that improvements can be measured.

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OBJECTIVES

The objectives of the QA source document are to identify, improve, consolidate, and document QA practices and procedures at all steps of the inventory development and review processes. Tools, procedures, and methods useful for inventory QA/QC were identified by surveying inventory experts in government agencies and in the private sector. These procedures are compiled in this document and linked to the appropriate category of sources or stages in the overall inventory process.

This QA source document is intended to be a "living" document that will be updated as needed. For example, several promising and potentially useful techniques for performing sensitivity analyses and statical checks on emissions estimates are presented in this document, but specific details on implementation are not included. The scope of the EIIP QA program does not extend to developing comprehensive "how to" steps for each method. Instead, an overview of methods is provided, with details and references to more detailed studies supplied where available. Future enhancements to this document will depend on the continuation of the EIIP itself, and on feedback from the users of this document.

Although this document focuses on the needs of state and local agencies, it can be used by anyone in government, industry, or research institutions who is concerned about inventory quality (general QA/QC information). For additional specific inventory QA/QC information, refer to the specific QA/QC sections of other EIIP technical documents.

A complete glossary of terms used in the QA/QC process is included in Volume I of this series. The methods and tools presented in this document are designed to reduce the number of procedural and technical errors. A procedural error is caused by the lack of clear and effective management of the QA/QC process including, but not limited to, inadequately trained staff, improper planning, lack of adequate QA, or lack of data tracking and handling protocols. Technical errors are directly related to the methods and technologies used to develop emission estimates. A technical error may result from the incorrect use of spreadsheets or emission inventory software; the use of incorrect data, methodology, and/or assumptions; mathematical miscalculations; or failure to include all emission sources. A good QC program is the best mechanism for minimizing technical errors; QA activities may catch technical errors as well, but less reliably.

Previously published EPA guidance documents have focused primarily on minimizing procedural errors. This volume includes some specific tools addressing technical errors and expands procedural QA tools.

The EIIP quality program is also concerned with providing tools to numerically evaluate emission inventories. One of these tools is the uncertainty analysis, which is an evaluation of the precision and accuracy of an emissions estimate. The most useful uncertainty analysis is quantitative and is based on statistical characteristics of the data such as the variance and bias of an estimate. However, uncertainty can be evaluated qualitatively using expert judgement. Typically, a nonnumerical ranking is used (e.g., "high" or "low" uncertainty).

Another quantitative tool is a sensitivity analysis. The effect of a single variable on the resulting emissions estimate generated by a model (or calculation) is evaluated by varying its value while holding all other variables constant. Sensitivity analyses can help focus QA/QC activities on the data that have the greatest impact on emissions estimates.

The remainder of this source document is organized as follows. Chapter 2, *Planning and Documentation*, discusses the vital role of planning and good QA/QC documentation. The minimum requirements for specific documents and examples are included. A time line showing where specific documents fit in the overall process is provided. Chapter 3, *General QA/QC Methods*, is a compilation of tools, procedures, and methods that can be used for QA/QC that are presented from simplest to most comprehensive. Chapter 4, *Evaluating the Uncertainty of Emission Estimates*, addresses sources of uncertainty and presents methods for evaluating the quality of emission estimates including rating systems and uncertainty analysis. Chapter 5, *Model QA Plan*, demonstrates how some of the information presented in the previous sections can be used in a QA plan. Although this section specifically targets state and local agencies that prepare regional inventories, the plan presented here can easily be adapted to other scales.

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REFERENCES

Boothe, L., and V. Chandler. 1994. *Quality Assurance of North Carolina Precursors of Ozone Inventories, Emission Preprocessor System and the Urban Airshed Model Output*. Presented at the 87th Air and Waste Management Association Annual Meeting and Exhibition, Cincinnati, Ohio, June 19-24.

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